Dynamic Controls on Sediment Accumulation Rates on the Northern Californian Shelf

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LONG-TERM GOAL

The overall goal of this study is to illuminate links between short-term sedimentary processes and centennial–millennial timescale stratigraphy by quantifying sediment accumulation rates on the U.S. north Pacific shelf and relating observed sedimentation patterns to major hydrologic, oceanographic and tectonic gradients.

OBJECTIVES

The objectives of this project are to (1) complete ^{14}C geochronological studies of piston cores collected previously on the Eel River and adjoining shelf systems as part of STRATAFORM; (2) interpret core-dating results in the context of sedimentological and sonar/seismic datasets available for the U.S. West Coast STRATAFORM study area; and (3) disseminate research findings through journal articles and the STRATAFORM master volume.

APPROACH

Sediment geochronology with ^{14}C ($t_{1/2}$=5730 yr) is an effective method for quantifying multi-millennial scale sediment accumulation rates, providing a means to link coastal sediment delivery, transport pathways and burial on continental shelves. For this study, a selection of piston cores collected on along- and cross-shelf transects during STRATAFORM research cruises (1995–1998) have been processed for ^{14}C dating using Accelerator Mass Spectrometry (AMS), with analytical work performed at the National Ocean Sciences AMS Facility, Woods Hole, Massachusetts. Reported ^{14}C data are age-corrected, calibrated, and integrated with gamma-density profiles to calculate both linear sedimentation rates (mm/yr) and mass accumulation rates (g/cm^2/yr). Spatial patterns in sediment accumulation are then related to fluvial-source magnitude and proximity, shelf hydrographic properties, and seismic stratigraphy (developed by other STRATAFORM scientists) to elucidate oceanographic and tectonic controls on sediment trapping and strata formation and preservation.

WORK COMPLETED

Work this year has focused on (1) processing of cores for ^{14}C dating and (2) dissemination of STRATAFORM research results. To date, a total of 70 samples have been analyzed for ^{14}C content resulting in sediment chronologies for 14 depositional sites (4–6 dates/core) between Cape Mendocino, California and Cape Blanco, Oregon, with an additional 4 chronologies in progress. Preliminary

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14. ABSTRACT
The overall goal of this study is to illuminate links between short-term sedimentary processes and centennial???millennial timescale stratigraphy by quantifying sediment accumulation rates on the U.S. north Pacific shelf and relating observed sedimentation patterns to major hydrologic, oceanographic and tectonic gradients.

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results were presented at the AGU Chapman Conference on the Formation of Sedimentary Strata on Continental Margins, Ponce, Puerto Rico, in June 2001. In addition, a manuscript based on a subset of the ^{14}C data was submitted to a peer-reviewed journal in August 2001.

RESULTS

Sediment accumulation from a fluvial line source

Piston cores dated for this study provide a 2000–7000 year history of terrigenous sedimentation on the U.S. north Pacific shelf, the most comprehensive dataset for this region. Sedimentation rates averaged on multi-millennial timescales range from a maximum of 5.9 mm/yr off the Eel River mouth, decreasing gradually to a minimum of 0.4 mm/yr just south of the Rogue River (Figure 1). The mean rate for all depositional sites is 1.8±1.7 mm/yr (1σ, n=14). The northward decrease in accumulation rate reflects, in part, the extremely high influx of sediment from the Eel River, which constitutes roughly 55 % of the total supply ($30x10^6$ tons/yr) from rivers between Cape Mendocino and Cape Blanco (Wheatcroft and Sommerfield, 1999). The steady along-shelf decline in accumulation rate, with no apparent discontinuity between the Eel and Klamath shelves, implies that these systems overlap at their northern and southern ends, respectively. Accordingly, it is likely that sediment derived from the Eel River is exported to the Klamath shelf during appropriate conditions of shelf flow, and vice versa, with significant implications to the sediment mass balance for the continental margin. In light of the new chronological data, a late-Holocene sediment budget for the greater U.S. north Pacific shelf is being developed based on the collective results of STRATAFORM and previous research studies.

Elucidating hydrographic and tectonic sediment trapping

A noteworthy new result, the ^{14}C-based sediment accumulation pattern is observed to be spatially coherent with that resolved by ^{210}Pb geochronology (Sommerfield and Nittrouer, 1999) and flood-layer mapping (Wheatcroft and Borgeld, 2001) as it exhibits a depocenter ~20 km to the northwest of the Eel River mouth. Such coherence is significant because it suggests that the strata forming conditions are time-transgressive, linked by common variables such as shelf circulation and/or antecedent shelf morphology. However, both hydrographic and tectonic mechanisms of sediment trapping are observed locally (Ogston et al., 2000; Berger et al., 2001), which complicates attempts to delineate respective roles in strata formation and preservation. For example, while the ^{14}C-based accumulation rates mirror seasonal–centennial sedimentation patterns, they also reflect tectonic framework, with high rates of accumulation over structural lows and low to negligible rates over structural highs (Sommerfield and Wheatcroft, 2001). One possible link between short-term transport processes and long-term stratigraphic products is bathymetric gradient, which influences deposition following Eel River flood events (Wright et al., 2001), but which is ultimately controlled by the tectonic regime.

On the completeness of marine sedimentary sections

Quantifying the timescale dependence of sediment accumulation rates in sedimentary basins is a useful approach to understanding the potential for strata preservation on the long term, given the well-known observation that rates tend to fall with increasing time span (Sadler, 1980). Departure from steady-state accumulation is a measure of episodicity and/or loss of sediment column (i.e., time) through erosion. To provide context for the present study, ^{14}C-based accumulation rates for the northern California–Oregon shelf are being compared to rates available for other sedimentary systems of the

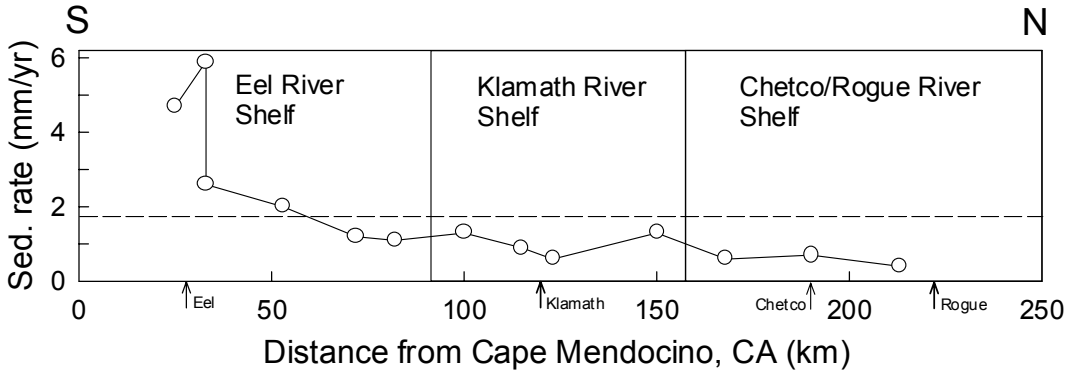

Figure 1. Plot of sediment accumulation rates on the U.S. Pacific shelf for a 70–100m depth transect showing an along-margin decrease with distance from Cape Mendocino, California. The dotted line marks the overall mean rate of 1.8 mm/yr. Arrows denote locations of the major rivers.

U.S. Pacific margin. An example of this analysis is shown in Figure 2. Sediment accumulation on the greater Eel–Klamath shelf, while more rapid, is more variable as a function of time span than in Santa Monica Bay (California), a sediment depauperate, low-energy marine environment (Figure 2). In other words, the Eel–Klamath stratigraphic record is less "complete" by comparison. This result illustrates that, despite the sediment-richness of the Eel–Klamath system, factors such as episodic sediment influx, wave resuspension, and perhaps tectonic movements on longer timescales, render the shelf record incomplete. The next step in this analysis is to determine the spatial variability of stratigraphic completeness within the Eel–Klamath shelf area as related to local oceanic and tectonics gradients.

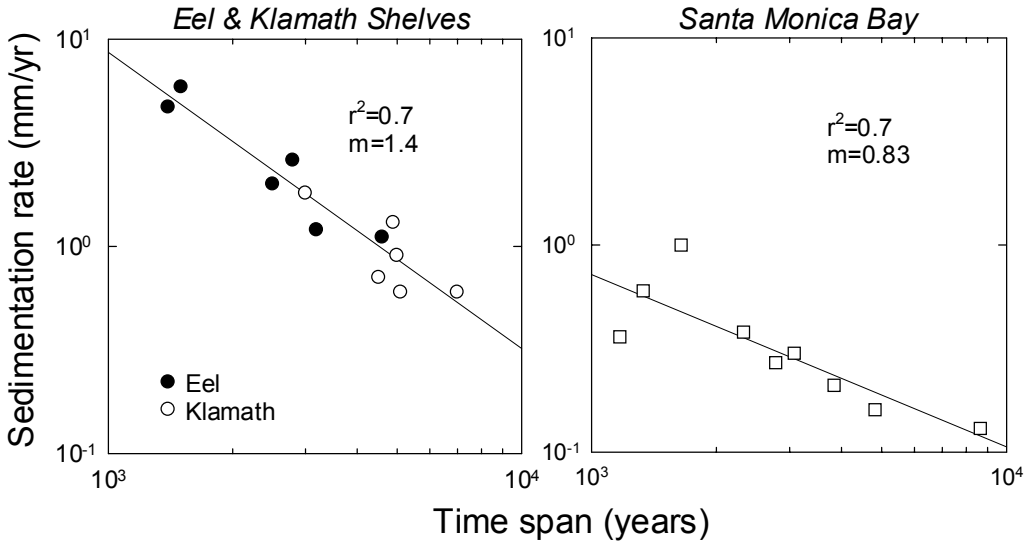

Figure 2. Plots of sediment accumulation rate as a function of time span (timescale of rate average) for the Eel–Klamath shelf and Santa Monica Bay based on ^{14}C geochronology. The slope (m) of the regression line is proportional to stratigraphic incompleteness; a fully complete record would plot as a horizontal line. Santa Monica Bay data are from Sommerfield and Lee (submitted).

IMPACT/APPLICATIONS

Knowledge of particle burial rates and strata formation with regard to depositional process is central to both fundamental (e.g., seafloor evolution) and applied (e.g., marine pollution) problems relevant to continental margin systems worldwide. Insight gained from this study will provide essential context for advancing conceptual and numerical models of continental shelf sedimentation and stratigraphy.

TRANSITIONS

Rigorously determined accumulation rates for sedimentary deposits are central to accurate numerical models of continental margin stratigraphy. The ^{14}C-based accumulation rates derived from this study have been made available to the STRATAFORM modeling community to support their efforts. In collaboration with Dr. R.A. Wheatcroft (Oregon State University), a sediment budget based on river-sediment fluxes and shelf sediment accumulation rates is being developed for the U.S. north Pacific shelf, the first system-integrated study of its kind. In addition, the P.I. is taking a lead role in authoring a chapter focusing on seasonal–millennial timescale strata formation to be included in the STRATAFORM master volume.

RELATED PROJECTS

The P.I. is collaborating with Drs. J. Goff and Dr. L. Mayer on ONR GeoClutter research by conducting sedimentological studies of cores collected within the U.S. East Cost STRATAFORM study area. While the focus of this work is determining the physical basis for sonar backscatter patterns in shallow-marine environments, new coring data will shed light on the formation of ravinement surfaces on continental shelves, a major objective of the STRATFORM Program.

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